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Effects of herbicides on weed density and wheat yield

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Abstract

The effect of four herbicides on weed density and wheat yield was studied. The experiment was laid out in randomized complete block design with four replications. The experiment consisted of four herbicidal treatments viz. Atlantis 3.6% WG (Ideo + mesosulfuron) at 0.40 kg ha^{-1}, Proton 50% WP (Isoproturon) at 2.00 kg ha^{-1}, Cleaner 70% WP (Isoproturon + bensulfuron) at 1.50 L ha^{-1}, Locker 70% WP (Fluroxypyr) at 0.25 kg ha^{-1}, and a weedy check. Results revealed that all the herbicides decreased total weed density and dry weight as compared to weedy check. The herbicide proton was found to be the most effective in reducing weed population as well as weed biomass with maximum mortality compared to those other three herbicides. Proton herbicide reduced total weed density by 86% and total weed dry weight by 89%, consequently wheat grain yield was increased by 40% over weedy check.
Key words: Herbicides, *Triticum aestivum*, weeds, yield.

Introduction

Weeds are hidden enemies of crops and severe weed infestation is one of the major constraints of low yield of wheat production in the countries of the world (Sanguankeo and Leon, 2011; Shehzad *et al.,* 2012). Weeds compete with crop plants for nutrients, solar radiation, water, carbon dioxide, space, and many other growth factors. Weeds cause massive losses to crop yields estimating Rs. 115 to 200 billion annually (Cheema and Khaliq, 2002). In Pakistan, weeds are accountable for 30% loss in wheat yield which account for loss of Rs.1150 million annually (Cheema and Akhtar, 2005; Gonzalez-Diaz *et al.,* 2007; Marwat *et al.,* 2008; Cavero *et al.,* 2011). Despite the facts that the use of chemicals deteriorates environment, herbicides are still the most common method of weed management (Montazeri, 2005). Grain yield of wheat is significantly increased by use of different chemicals for weed management (Chaudhry *et al.*, 2008; Hesammi1 *et al*., 2010). Hence, weed management becomes an indispensible for inspiring increase in crop production. Weeding, manually or through animal drawn implements is not only ineffective but also very expensive because of increased cost of labour and fuel. Under such circumstances, judicious use of herbicides is the only suitable approach for effective weed management which is also economical (Fayad *et al.,* 1998). Highest grain yield was achieved through the application of herbicides at the first weed development stage (Barros *et al.,* 2009). Singh *et al*. (2013) reported that the application of Metsulfuron and 2, 4-D at 6 g ha^{-1} and 500 g ha^{-1} as post emergence reduced weed population, weed biomass and weed index by 78.3%, 67.4% and 23.5%, respectively and increased wheat grain yield by 37.8% as compared to weedy check.

Both mono and dicot weeds grow in the wheat field in semiarid conditions of the region. Therefore, the present study was conducted to evaluate the post emergence application of four different herbicides on weed management and growth and yield management of wheat crop.

Materials and Methods

Site description

To assess the impact of different herbicides on weeds and performance of wheat, a field experiment was conducted at Adaptive Research Farm, Sheikhupura, Pakistan; situated at 31°-32.5°N latitude, 73.5°-74.42° E longitude and at 209 m above sea level. Due to high evapo-transpiration, Sheikhupura features a semi-arid climate with mean annual rainfall of about 250-500 mm. The soil of the experimental site was a sandy clay loam with proportion of sand, silt and clay as 49.25%, 22.55% and 28.20%. Soil pH and EC was 8.1 and 0.88 dSm^{-1}, respectively. The organic matter, total nitrogen, available phosphorus and potassium were 0.70%, 620 mg kg^{-1}, 16 mg kg^{-1} and 174 mg kg^{-1}, respectively.

Experimentation

Wheat variety Seher-2006 was planted with single row hand drill using 125 kg ha^{-1} seed in a

Randomized Complete Block Design (RCBD) on November 23, 2010. The experiment consisted of four post emergence application herbicides with three replications for each chemical and a weedy check for comparison (Table 1). The net plot size was 1.5 m × 8 m. Weather conditions during the course of study are given in Table 2. Fertilizer was applied at 128 kg N, 114 kg P_2O_5 and 62 kg K_2O ha^{-1} in the form of urea, diammonium phosphate (DAP) and sulphate of potash (SOP), respectively. The whole P, K and one third of N was applied at sowing and remaining two third of the N was applied with first irrigation. Four irrigations excluding rauni were applied at crown root initiation, boot, and anthesis and grain development stages. All other agronomic practices except those under study were kept normal and uniform for all the treatments.

Data collection

Data on weed dynamics (density, dry weight) were recorded at two randomly selected places in each plot after the herbicidal spray with the help of a quadrate (0.5 m × 0.5 m) in size and subsequently the average values were converted to the density m^{-2}. Weeds were counted individually and clipped at ground level to record their biomass. Weed dry weight was recorded after drying in an oven at 70 ºC for 48 h. The crop was harvested on April 23, 2011 and threshed mechanically with a mini thresher. From each experimental unit, an area of one square meter was taken at random to record observations. Observations on number of productive tillers per unit area, number of grains per spike, 1000 grain weight, straw yield and grain yield were recorded by using standard procedures.

Statistical analyses

All the data collected were subjected to Fisher's analysis of variance technique (Steel *et al.,* 1997) using the MSTATC statistical package. To ascertain the relationship between different variables, regression analysis was also done using MS-Excel.

Results and Discussion

Natural weed flora at experimentation site consisted of little seed canary grass (*Phalaris minor* Retz.), yellow sweet clover (*Melilotus parviflora* Desf.), lesser swine cress [*Coronopus didymus* (L.) Sm.], toothed dock (*Rumex dentatus* L.), wild oat (*Avena fatua* L.), blue pimpernel [*Lysimachia monelli* (L.) U. Manns & Anderb.], lamb's quarters (*Chenopodium album* L.), purple nut sedge *Cyperus rotundus* L., toothed bur clover (*Medicago denticulata* Willd.) and field bind weed (*Convolvulus arvensis* L.).

Influence of herbicides on density and dry weight of weeds

Weed density per unit area is an important and key parameter in figuring out the impact of treatments on weed growth. The statistical analysis of the data revealed that all treatments (herbicides) significantly ($P \leq 0.05$) suppressed total weed density as compared with control (Table 3). Among herbicidal treatments, minimum number of weeds (8.50 m^{-2}) was recorded in Proton treated plots and it was followed by Atlantis (15.10 m^{-2}) which was comparable with Cleaner in which 20.09 weeds were counted. Arif *et al.* (2004), Khan *et al.* (2004) and Chhokar *et al.* (2007) also recorded significant reduction in weed growth with the application of herbicides. The least weed density and dry biomass in herbicide treatments could be most probably due to their phytotoxicity against diverse and disruptive weed flora. These findings were in harmony with that of Khan *et al*. (2001). They reported that grass and broadleaf weeds were controlled very effectively by the application of herbicides. The present results were also in conformity with earlier findings (Hassan *et al*., 2003; Khan *et al*., 2004; Jarwar *et al*., 2005), who reported that chemical weed management method was found to be highly effective and economical approach. Almost similar trend was found in reducing total weed dry weight in wheat crop by different herbicides (Table 3).

Influence of herbicides on number of fertile tillers

The effect of different herbicides was significant ($P \leq 0.05$) for number of fertile tillers m^{-2} of wheat crop (Table 4). The maximum (321) number of fertile tillers m^{-2} was observed in plots treated with Proton and minimum (228) number of fertile tillers m^{-2} were recorded in weedy check. Atlantis and Cleaner were statistically equal to each other with 291 and 273 fertile tillers m^{-2}, respectively. The similar findings were described by Khan *et al*. (2003a). They reported that number of fertile tillers per plant was significantly increased with application of herbicide for weed management in wheat crop.

Influence of herbicides on number of grains per spike

Among the yield components, number of grains per spike is imperative parameter for assessment of the impact of weed management treatments on yield. Increasing the number of grains per spike will increase the weight of the spike which in turn definitely improves the ultimate yield. All the weed management treatments significantly boosted the number of grains per spike. Different chemical treatments had significant ($P \leq 0.05$) effects on grains per spike (Table 4). The highest numbers of grains per spike (51) of wheat was found in Proton treated plots followed by Atlantis with 49 grains per spike and both were statistically ($P \leq 0.05$) at par with each other, while Cleaner and Locker produced 45 and 42 grains per spike, respectively and both were statistically equal to each other. The lowest number of grains (34) was calculated in weedy check plots. This could be attributed to lower number of weeds in herbicidal treatments which resulted in more absorption of nutrients from soil due to less competition. Likewise, Hassan *et al.* (2003) also reported that the increase in number of grains per spike that may be attributed to better weed management and abolition of weed crop competition for nutrients, moisture and light and better use of available resources by the crop.

Influence of herbicides on 1000-grains weight

Different herbicides significantly ($P \leq 0.05$) affected 1000-grains weight (g) of wheat crop (Table 4). The highest 1000-grains weight of 43.20 g was observed in plots treated with Proton herbicide which was statistically equal to Cleaner and Atlantis with 42.70 and 40.40 g of 1000-grains weight, respectively. The lowest 1000-grains weight (30.80 g) was observed in weedy check plots. The maximum 1000-grains weight in proton treated plots was due the efficient management of grassy and broad-leaved weeds, which provided an ample opportunity for the crop to utilize the available resources to increase grain weight. Similar impact of weed management on 1000-grains weight has also been described previously (Khan *et al*., 2003b; Mahmood *et al.,* 2012).

Influence of herbicides on grain yield

Grain yield is the main and prime parameter for estimation of any weed management treatments applied in experimentations. Significant ($P \leq 0.05$) effect on wheat grain yield was noticed among the various herbicides (Table 4). The maximum grain yield (3560 kg ha^{-1}) was produced in plots treated with Proton which was statistically at par with Atlantis herbicide (3382 kg ha^{-1}). Atlantis and Cleaner herbicides were also statistically equal to each other with grain yield of 3382 and 3095 kg ha^{-1}, respectively. Due to maximum infestation of weeds, the lowest wheat grain yield (2536 kg ha^{-1}) was recorded in the weedy check plots. Wheat yields were negatively associated with weed density and dry weight as denoted, and regression accounted for 88 and 85% of variation in yield due to density and dry weight of weeds (Fig. 1a & 1b).

The highest grain yield in Proton treated plots is attributed to the better management of grassy and broad-leaved weeds by this treatment and thus the crop was able to utilize the available resources more efficiently. The similar findings were reported by earlier researchers (Hassan *et al.,* 2003; Tunio *et al.,* 2004; Arif *et al*., 2004; Hesammi *et al.,* 2010; Mahmood *et al.,* 2012; Shahzad *et al.,* 2012; Hussain *et al.,* 2013; Singh *et al.,* 2013), who reiterated the effectiveness of herbicide applications having been influential in raising the grain yield of wheat.

Influence of herbicides on straw yield

Statistical analysis of the data showed that all the herbicidal treatments had significant ($P \leq 0.05$) effect on the straw yield (kg ha^{-1}) of wheat (Table 4). The maximum straw yield of 3880 kg ha^{-1} was observed in Proton treated plots followed by Atlantis and these both were statistically at par with each other while the minimum straw yield (2740 kg ha^{-1}) was produced in the weedy check plots. The straw yield in Cleaner (3220 kg ha^{-1}) and Locker (3080 kg ha^{-1}) treated plots was statistically equal to each other. The highest straw yield could be owing to the better management of mono and dicot weeds by herbicidal treatments particularly Proton and thus the crop was capable to make use of the available resources more proficiently. The similar findings were reported previously by researchers (Khan *et al.,* 2003b; Singh *et al.,* 2013). They illustrated that straw yield was significantly increased with the application of herbicide for weed management in wheat crop.

Conclusion

The findings of the present study indicate that Proton 50% WP (Isoproturon) herbicide at 2.00 kg ha^{-1} controlled weeds very effectively and enhanced grain yield of wheat and it can be successfully used for managing both grassy and broadleaf weeds in wheat crop.

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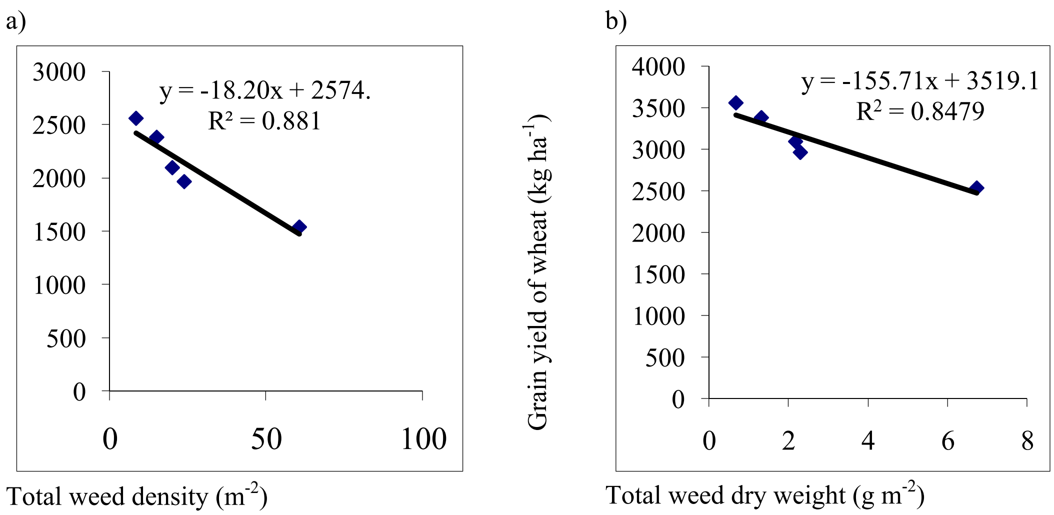

Fig. 1: Relationship between total weed density (a), and total weed dry weight (b) with wheat grain yield.

Table 1: Post-emergence herbicides used in wheat during Rabi 2010-11

Herbicides	Trade name	Rate
Iodo+mesosulfuron	Atlantis 3.6% WG	0.40 kg ha^{-1}
Isoproturon	Proton 50% WP	2.00 kg ha^{-1}
Isoproturon+bensulfuron	Cleaner 70% WP	0.25 k g ha^{-1}
Fluroxypyr	Locker 75% WP	1.50 L ha^{-1}

Table 2: Meteorological data of the experimental site during the course of study.

Months	Temperature (°C)			Humidity (%)	Rainfall (mm)	Pan Evaporation (mm)	Sun shine (h)	Wind Speed km h^{-1}
	Min.	Max.	Avg.					
Nov., 2010	13.03	27.58	20.31	55.56	0.00	2.6	8.4	2.7
Dec., 2010	5.42	21.60	13.50	66.54	3.00	1.2	7.4	3.3
Jan., 2011	2.77	13.42	8.09	68.17	0.00	1.4	5.3	4.5
Feb., 2011	6.43	18.57	12.5	64.41	17.00	1.6	5.6	5.8
Mar., 2011	13.26	27.99	20.62	58.45	12.10	3.7	8.6	5.9
Apr., 2011	18.02	31.89	24.96	42.83	0.00	5.8	9.4	7.4

Source: AgroMet Observatory o/o District Officer of Agriculture (Extension), Sheikhupura.

Table 3: Effect of different herbicides on total weed density and total weed dry weight.

Treatments	**Total weed density (m^{-2})**	**Total weed dry weight ($g\ m^{-2}$)**
Weedy check	60.70 a	6.74 a
Atlantis @ 0.40 kg ha^{-1}	15.10 c (-75.12)	1.32 cd (-80.48)
Proton @ 2.00 kg ha^{-1}	8.50 d (-86.00)	0.68 de (-89.98)
Cleaner @ 1.50 L ha^{-1}	20.09 bc (-66.90)	2.18 c (-67.72)
Locker @ 0.25 k g ha^{-1}	23.90 b (-60.63)	2.30 b (-65.94)
LSD ($P \leq 0.05$)	4.30	0.68

Means sharing same letters in a column do not differ significantly at $P \leq 0.05$. Figures given in parenthesis indicate percent decrease over control.

Table 4: Effect of different herbicides on growth, yield and yield components of wheat.

Treatments	Number of fertile tillers (m^{-2})	Spike length (cm)	Number of grains $spike^{-1}$	1000-grain weight (g)	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Weedy check	227.60 e	7.50 d	33.65 d	30.80 c	2740 c	2536 d
Atlantis @ 0.40 kg ha^{-1}	290.80 b	9.65 b	49.00 ab	43.20 a	3735 a	3382 ab (40.37)
Proton @ 2.00 kg ha^{-1}	320.60 a	10.39 a	51.29 a	40.40 ab	3880 a	3560 a (33.35)
Cleaner @ 1.50 L ha^{-1}	272.50 bc	9.31 b	45.00 bc	42.70 ab	3220 b	3095 bc (22.04)
Locker @ 0.25 kg ha^{-1}	263.70 cd	8.65 c	42.33 c	37.50 b	3080 b	2964 c (16.87)
LSD ($P \leq 0.05$)	28.40	0.57	4.94	3.95	152.1	388

Means sharing same letters in common do not differ significantly at $P \leq 0.05$. Figures given in parenthesis indicate percent increase over control.

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